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REPORT NO. 248

EXPERIMENTAL DATA FORMING THE BASIS FOR THE BOMBING TABLES BT-100-B-3 FOR THE BOMB, PRACTICE, 100-LB., M38A2

by

E. S. Martin Ellen Boyle

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U.S. ARMY ABERDEEN RESEARCH AND DEVELOPMENT CENTER BALLISTIC RESEARCH LABORATORIES ABERDEEN PROVING GROUND, MARYLAND

Ballistic Research Laboratory Report No. 248

ESM:EB/ess Aberdeen Proving Ground, Md. March 4, 1942

BRL, APG, MD.

EXPERIMENTAL DATA FORMING THE BASIS FOR THE BOMBING TABLES

BT-100-B-3
FOR THE

BOMB, PRACTICE, 100-LB., M38A2

Abstract

This report records the essential data on which the bombing tables BT-100-B-3 are based. A short description of the bomb is given as well as the mechanical constants of the bombs used. The methods used in range bombing and the methods of obtaining essential data are described. The methods used to determine the ballistic coefficients as well as the methods used in constructing the bombing tables are also given. Graphs showing the results of range bombing and graphs showing the fitted C: Y relations are included.

1. Purpose of Report

The purpose of this report is to record the essential details of the experimental work, the computing methods and the experimental data upon which the bombing tables BT-100-B-3 for the Bomb, Practice, 100-1b., M38A2 are becomesty of U.S. ARMY STINFO BRANCH

II. <u>Description of Bombs</u>

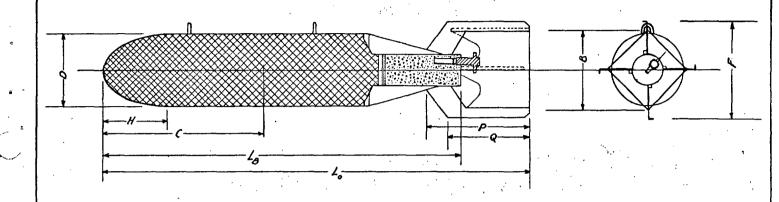
The Bombs, Practice, 100-1b., M38A2 used in range bombing for the bombing tables BT-100-B-3 were made in accordance with Ordnance Department Drawing Number No. 82-0-23 dated December 24, 1937and revised April 29, 1938.

III. Preparation of Bombs

The following page gives an outline drawing of the Bomb, Practice, 100-1b., M38A2 with weights and measurements which were prescribed for range bombing and obtained from observations.

The bomb is made of relatively thin sheet metal and is stored and shipped to the place of issue empty to keep handling

PHYSICAL CHARACTERISTICS BOMB, PRACTICE, 100-1B., M38 A2 DRG. NO. 82-0-23 REV. 4-29-38



	PAINCIPA	IL DINLIVIONS	
INCHES	CALIBERS	REMARKS	
8.0	1.00	AS GIVEN ON DRAWING	
8.5	1.06	AS GIVEN ON DRAWING	

В 10.75 AS GIVEN ON DRAWING 1.34 47.5 AS GIVEN ON DRAWING Lo 5.94 5.08 AS GIVEN ON DRAWING LB 40.6 AS GIVEN ON DRAWING Η 7.1 0.89

DIMENSION D

P 11.4 1.42 AS GIVEN ON DRAWING
Q 9.1 1.14 AS GIVEN ON DRAWING

C 18.14 0=0.242 2.27 MEAN FROM RANGE BOMBING
C 18.16 ± .25 OF BODY ASSEMBLY AS PRESCRIBED FOR RANGE BOMBING WITH TOLERANCE

COMPONENTS AND WEIGHTS

C 0777 0 11 21 1 7	7,2,	
COMPONENTS	WEIGHT (28.)	REMARKS
BODY	15.7	AS GIVEN ON DRAWING INCLUDING SUSPENSION LUGS AND FINS
SPOTTING CHARGE ASSEMBLY	1.25	LESS SPOTTING CHARGE
SPOTTING CHARGE	3.0	BLACK POWDER (SODIUM NITRATE)
FILLER	80	SAND - AS GIVEN ON DRAWING
·		
	.,	
PLETE AS DROPPED	100	AS GIVEN ON DRAWING
PLETE AS DROPPED	99.30=0.85	MEAN FROM RANGE BOMBING
	COMPONENTS BODY SPOTTING CHARGE ASSEMBLY SPOTTING CHARGE FILLER PLETE AS DROPPED	BODY SPOTTING CHARGE ASSEMBLY SPOTTING CHARGE 3.0 FILLER 80 PLETE AS DROPPED 100

EXPECTED MAXIMUM VARIATION IN WEIGHT AS LOADED = ±2.57

RATIO: WEIGHT OF BURSTING CHARGE: WEIGHT AS DROPPED = --

EXPERIMENTAL DESIGNATION: STANDARDIZED BY: OCM

PREPARED IN BAL. RES. LAB. A.P.G. -2-

KS 138

and shipping costs as low as possible. At the point of issue it is loaded to weight with sand and the spotting charge MIAI is assembled to it before it is turned over to the Air Corps for use. In order to obtain the highest uniformity of flight of which the bombs are capable it is necessary that the variation in mechanical constants from bomb to bomb be kept as small as possible. In order to accomplish this, the bombs used in these range bombings were loaded with a mixture of sand and cinders in which the proportion of these two materials was adjusted to give the mixture a density such that the specified weight of the completely assembled bomb was obtained when the cavity of the bomb was completely filled. Before being loaded into the bomb the mixture was carefully blended in order to secure a uniform density.

The adequacy of this method of loading is indicated by the evidence cited in the next paragraph of this report and the relatively narrow probable error of forecast bands for the fitted relations between the ballistic coefficients and the altitude of release. These relations and the corresponding probable error of forecast bands are shown in Appendix D. If it is desired to obtain results of equal precision in the field it is recommended that a similar method of loading be prescribed. Failure to employ a systematic control in loading results in a wide dispersion in the mechanical donstants of bombs and correspondingly wide dispersion in their flight characteristics.

IV. Mechanical Constants of Bombs

The mechanical constants of each bomb were determined before it was loaded into the airplane. The detailed results of these measurements are given in Appendix A. A summary of the results obtained is given in the table below.

A more complete description of the method used in order to control the mechanical constants of the bombs used in the range bombing program is given in a memorandum prepared in the Ballistic Research Laboratory: "Procedure for Determination of the Mechanical Constants of Bombs".

	m	x	IL	I _T
	Weight		Moment of	Moment of
	Complete		Inertia	Inertia about
	as	of Gravity		Transverse
	Dropped	from Nose	Longi-	Axis through
		٠.,	tudinal	Center of
			Axis¹	Gravity
	lb.	in.	lb.ft. ²	lb.ft. ²
Mean	. 99.3	18.14	5.410	76.06
Standard Deviation	0.85	0.24	0.052	1.31
Maximum	102.0	18.76	5.546	79.50
Minimum	98.0	17.75	5.294	72.64
Number of Bombs	99	99	41	99

These statistics refer to all bombs for which a ballistic coefficient with respect to any element was obtained. The actual variation in weight of these bombs does not affect the flight characteristics of the bombs sufficiently to cause a variation in ballistic coefficient large enough to be detected by the methods for estimating the ballistic coefficient which were used in the reduction of the field data. The variation in center of gravity position and moments of inertia would, if sufficiently in excess of that for the present bombs, affect the yaw of the bombs and thereby the dispersion in the elements range, time of flight and trail. The small dispersion in the mechanical constants for these bombs indicates the efficacy of the method of loading described in this report.²

V. Description of the Range Bombing

The bombs in this range bombing program were dropped from the Bl8, B-4, B-4A, B-18A and B-17B airplanes at a target anchored in Bush River in such a position that the release point was in the fields of view of the Vertical and Oblique Cameras Obscura. The direction of the approach to the release point on all runs was from southeast to northwest within approximately 15°.

On all approaches on which bombs were dropped, horizontal flight was maintained as nearly as possible. In the case of the B-18, B-18A, B-4 and B-4A the piloting was done by manual control. In the case of the B-17B airplane the piloting was done by automatic control.

The spotting charge accombined to the B-17B.

The spotting charge assembled to the Bomb, Practice, 100-1b., M38A2, was modified after 41 measures of I_L were made. The adapter used to permit axial rotation of the bomb in order to measure I_L could no longer be used and consequently only 41 measures of this moment of inertia were made.

Thmore complete description of the method followed in controlling the mechanical constants is given in Ballistic Research Laboratory Report No. 190: "The Computation of the Mechanical Constants of Bombs".

In these airplanes the bomb racks are so arranged that the longitudinal axis of the bomb is nearly parallel to the thrust line of the airplane. Hence the initial yaw of the bomb in the vertical plane is nearly equal to the angle of attack of the airplane.

On all approaches with the B-18 and the B-18A airplane the bombs were carried in the rear bank of the bomb racks. The center line of this rack is 12.8 feet to the rear of the point formed by the junction of the front edge of the wing with the fuselage of the airplane at which point the airplane is plotted in the cameras obscura. In the B-4 airplane there is a single bank of bomb racks. The corresponding distance is 3.7 feet. In the B-17B airplane the corresponding distance is 6.4 feet for all the bomb rack stations used in range bombing.

All bombs were dropped according to the current standard bombing practice of the Air Corps using the current standard bomb sight and a target in Bush River as an aiming point. The idequacy of the bombing technique is indicated by the results shown in Appendix B. The displacement of the center of impact with respect to the target results in part from the fact that the bombing tables available to the bombardier were based on roughly approximated values of the ballistic coefficients and, for the purpose of this report, are of no special significance. The dispersion about the center of impact and other data summarized in Appendix B are, however, of considerable interest.

The bombs dropped were divided into groups and the endeavor made to make the altitude and air speed within a group approximate as nearly as possible to certain specified values. These values were described as the standard altitude and standard air speed.²

The number of bombs in each group and the standard altitude and air speed for each group are given in Appendix D. The reasons for the selection of these standard altitudes and air speeds are given in sections VI and IX of this report.

The effect of the bomb bay release position on the estimated values of the ballistic coefficients is discussed in Ballistic Research Laboratory Report No. 136: "First Progress Report: On the Method of Reduction of Observations on the Elements of Bomb Trajectories".

² Compare the usage of these terms for statistical purposes in Sections VIII and IX of this report.

The range bombing was conducted by the following:

Pilots:

Capt. D. W. Watkins, A.C.
Capt. C. S. Thorpe, A.C.
First Lt. L. H. Tull, A.C.
First Lt. B. A. Schreirer, A.C.
Second Lt. C. A. Peterson, A.C.
W.O., J. A. Lee, Sr.
Master Sgt. S. C. Smink, A.C.

Bombardiers:

Capt. C. S. Thorpe, A.C. First Lt. M. F. Summerfelt, A.C. Master Sgt. S. C. Smink, A.C.

Proof Officers:

First Lt. R. G. Butler, O.D. First Lt. J. H. Weber, O.D. First Lt. J. A. Barclay, Jr., O.D. First Lt. J. D. Armitage, O.D. First Lt. J. G. Shinkle, O.D.

VI. Ground Observations

The primary ground observational equipment employed was the Camera Obscura Installation. The position of the aircraft in space and its components of velocity were fundamental data obtained by reduction of observations made with this equipment.

The field data for determination of times of flight were secured by the chronograph installation housed in the Vertical Camera Obscura. The instants of release and impact were recorded by this chronograph - hydrophone system which has been in use in the present form since 1937.

The basic description of the Camera Obscura Installation is given in the "First, Second and Third Progress Reports on Bomb Trajectory Study by the Camera Obscura Method" by Frank Short, F. V. Ludden and S. P. Willan. The equipment has been extensively modified and improved during 1938 and the current equipment and accuracy are described in the Ballistic Research Laboratory Report No. 144: "First Progress Report: On the Accuracy of the Camera Obscura Installation for Obtaining the Initial Data of Bomb Ballistics".

The calibration of the chronograph-hydrophone system and the measurement of the systematic errors to which it is subject were carried out in 1938 and are described in Ballistic Research Laboratory Report No. 130: "On the Measurement of the Time of Flight of Bombs". The absolute accuracy and internal precision of the method in actual practice has been recently determined and the results are given in Ballistic Research Laboratory No. 211: "Comparison of Measures of the Time of Flight of Bombs by the Camera Obscura Chronograph and the Western Electric Clock".

The coordinates of the impacts referred to the camera coordinate system were obtained by the ground observers by means of three azimuth instruments on towers along the shore of Bush River and furnished to the Bombing Unit of the Ballistic Research Laboratory. The dispersion data with reference to the target, the reduced meteorological data for securing corrections to the elements tabulated in the bombardier's approximate bombing tables, and the corrections obtained from these meteorological data were also provided by the ground observers. The latter graphically summarized results are given in Appendix B, "Primary Results of Range Bombing".

The field data necessary for the reduction of the effects of non-standard meteorological conditions were obtained from two sources. The data secured by the camera observers were the coordinates on the camera plotting boards of smoke puffs at regular intervals for a series of altitudes, the velocity and direction of the wind at the surface of the ground and the barometric pressure of the air at the surface of the ground. The data secured by the Range Observation Section observers were the spatial positions of a balloon at regular intervals and the velocity and direction of the wind at the surface of the ground. The temperature and barometric pressure at a series of altitudes above the ground were obtained from the bombing flight records of the bombardier. These data were partially reduced by the Range Observation Section and were furnished to the Bombing Unit in the form of tables of:

- (1) The actual wind components, and
- (2) The density of the air relative to standard ordnance air density structure, each at a series of altitudes.

The wind components were taken as positive along the bombing lane and to the right of the bombing lane. The bombs were dropped during the interval between two wind measurements.

Field data on range bombing with the Bomb, Practice, 100-1b., M38A2 were obtained in part from the program cafried out between May 21, 1937 and May 25, 1938. A systematic bombing program was selected containing four altitude groupings at 6,000, 9,000, 12,000 and 15,000 feet and carried out between March 9, 1938 and May 25, 1938. The advance of ballistic theory and increased accuracy of measurement during 1938 and

1939 showed that better results can be obtained from groupings at a great altitude of release, a central altitude and a low altitude. Consequently the range bombing program for this bomb was extended during 1939 to include groups at altitudes of release of 20,000 feet and 2,000 feet. These bombs were dropped during the interval between May 3, 1939 and July 17, 1939. In addition, data drawn from the program for determination of the effect of speed of release upon ballistic coefficient for the M38A2 at 7,000 feet altitude of release have been employed. This program was carried out between October 31, 1938 and November 10, 1938. On June 21 and July 5, 1940 range bombing was obtained at an approximate altitude of 25,000 feet. Field data were obtained for determinations of range and time of flight for 99 bombs. Trail determinations were made from the reduced ranges and times of flight when it was possible. A total of 82 times of flight and 82 trails were obtained.

VII. Reduction of Field Data

The data secured by the ground observers at the cameras were utilized to obtain the position and velocity of the airplane at the instant of release. The data secured by the ground observers at the azimuth instruments were utilized to obtain the position of impact of the bombs. The time interval resulting from the chronograph strip was employed to determine the uncorrected interval in time. These data were then corrected for instrumental errors. 1

VIII. Determination of Ballistic Coefficient

The reduction of the field data furnishes values of the range and time of flight corresponding to a certain set of known values of altitude and air speed, but containing the effects of departures from standard ballistic table conditions. The preparation of a bombing table requires a set of elements which are correct under standard bombing table conditions. The effects of departures from standard bombing table conditions must in the main be removed from the unreduced ranges and times of flight. When standard ballistic table conditions differ from standard bombing table conditions, the effects of these differences are allowed to remain in the reduced ranges and times of flight. The preparation of the bombing table requires the equivalent of a knowledge of the range and time of flight corresponding to all attainable altitudes and air speeds. The procedure is to determine values of the

¹ The character of these instrumental errors is discussed in Ballistic Research Laboratory Reports No. 144, 130 and 211, previously cited.

² Standard ballistic table conditions and standard bombing table conditions are discussed and compared in Ballistic Research Laboratory Report No. 145: "On the Theory of Motion of the Bomb".

ballistic coefficients for the observed elements and compute bombing table elements for the other cases by interpolation or extrapolation of the ballistic coefficients.

The computation of the ballistic coefficients is carried out by means of a Bomb Ballistic Reduction Table. The standard ballistic table conditions under which the Bomb Ballistic Reduction Table is computed include the assumption that the only air force acting on the bomb is the drag and that this depends on velocity according to the Gâvre law. Because of these and other differences between standard ballistic table conditions and standard bombing table conditions, there occur not only variations in C with altitude and air speed but the value of C required to give the correct range is different from that required to give the correct time of flight and that for trail is different from either.

In accordance with these principles the ballistic coefficients corresponding to the ranges, times of flight, and trails were then deduced for each individual bomb. From these coefficients the ranges, times of flight and trails were computed for the standard altitude and standard air speed of the group to which the bomb belonged. These are called the "standard ranges", "standard times of flight" and "standard trails", or in general the "standard elements" and are given in Appendix C together with the corresponding ballistic coefficients. This appendix also lists the program, the group, the serial number stamped on the bomb, the date of release and the run number which is called "Bomb No." in "Results of Range Bombing" contained in Appendix B. The last two provide for comparison with Appendices A and B.

The standard elements and the ballistic coefficients corresponding thereto contain the effects of certain unknown instrumental inaccuracies and of certain departures from standard bombing table conditions which it was not feasible to remove in advance. However, the effects of these sources of dispersion were partially removed by the process used for the construction of the bombing table.

The method of reduction of field data in order to obtain ballistic coefficients with respect to range, time of flight and trail has undergone considerable evolution. The reports from which the present methods were developed include: Ballistic Research Laboratory File E-IV-3: "Explanations and Comparisons of the Camera Obscura Methods of Computation", "Computation of Firing Tables for the U.S. Army" and Ballistic Research Laboratory Report No. 136, previously cited.

² The table used in reduction of the data discussed in this report was prepared in the Ballistic Research Laboratory.

³ A discussion of the ballistic coefficients corresponding to range, time of flight and trail is given in Ballistic Research Laboratory Report No. 143: "Errors in Trail Resulting From Ignoring Either the Measured Range or the Measured Time of Flight".

IX. Construction of Tables

The experimental data from which the ballistic coefficients with respect to range, time of flight and trail were determined, fell into 8 altitude groups. The groups were for standard release altitudes of 25,000, 20,000, 15,000, 12,000, 9,000, 7,000, 6,000 and 2,000 feet. The groups at 15,000, 12,000, 9,000 and 6,000 feet were employed in construction of the Bombing Table BT-100-B-1. They were all obtained during 1938. The 7,000 foot groups were obtained incidentally to the range bombing program undertaken to determine the effect of speed of release upon ballistic coefficient. The later bombing programs were determined uniformly for release altitudes of 2,000, 10,000 and the maximum obtainable since it was found that this plan resulted in the greatest amount of ballistic information with the greatest economy in the bombing program. Consequently the range bombing program of 1939 added the groups at 20,000 and 2,000 feet. In 1940 range bombing was carried out for an altitude group of 25,000 feet. The dependence of the ballistic coefficients upon altitude of release were thus well determined.

The mean standard elements for a standard true air speed and altitude were determined for each altitude group. The mean standard element is the arithmetic mean of the individual standard elements. The individual standard elements used in computing the mean standard elements had of course, been reduced to the group standard altitude and true air speed. The use of the mean standard elements reduces the influence of accidental errors in the individual standard elements upon the elements tabulated in the bombing table. The ballistic coefficients corresponding to these mean standard elements were then deduced. The forms of the functional dependence upon altitude of the three ballistic coefficients have been derived theoretically and verified empirically. The lift is the cause mainly responsible for the character of the variation of the ballistic coefficients with altitude. The lift is due to the yaw arising from the initial angular velocity of the tangent to the The effects of lift are allowed to remain in the trajectory. ballistic coefficients corresponding to the mean standard elements. The functional relations referred to are:

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¹ The derivation of the form of these relations between the ballistic coefficient and the altitude of release is discussed in Ballistic Research Laboratory Report No. 145, previously cited.

$$c_{X_{y}} = \frac{c_{X_{\infty}}}{\frac{1}{1 + \frac{k_{X}C_{X_{\infty}}}{\sqrt{Y}}}}$$

$$c_{T_{y}} \stackrel{=}{=} \frac{c_{T_{\infty}}}{\frac{k_{T}C_{T_{\infty}}}{\sqrt{Y}}}$$

$$c_{\lambda_{y}} = \frac{c_{\lambda_{\infty}}}{\frac{k_{\lambda}C_{\lambda_{\infty}}}{\sqrt{Y}}}$$

These curves each contain two empirical quantities k and C_{∞} . The subscript ∞ refers to the mean effective ballistic coefficient for infinite altitude, and k is a parameter determining the shape of the curve.

A new procedure for estimating the values of $C_{X_{\infty}}$, $C_{T_{\infty}}$, $C_{X_{\infty}}$, k_X , k_T and k_λ was introduced between the date when bombing tables BT-100-B-2 were issued and the date when bombing tables BT-100-B-3 were issued. The new procedure involved two principal modifications in the method of estimation:

(1) An improved assignment of weights to the altitude groups, and

(2) Direct minimization of the weighted squares of the residual differences between the mean standard elements and those elements which would result from the use of the bombing tables. This modification has resulted in much smaller probable ballistic errors for bombing tables. The improvement is shown by the reduced magnitude of the differences between the observed mean standard ranges, times of flight and trails and those elements which would result from employment of these tables. The values C_{X_∞} , C_{T_∞} , C_{λ_∞} , k_X and k_λ were deduced by this new

procedure: \mathbf{k}_{T} was shown to be without significance in the present instance.

A brief description of the new procedure is given in Ballistic Research Laboratory Report No. 224: "Experimental Data Forming the Basis for the Bombing Tables BT-1000-A-1 for the Bomb, Demolition, 1000-1b., M44".

The ballistic error is a term originally used by British ballisticians to denote the difference between the bombing table range and the mean standard range for the same conditions. The ballistic error is denoted by X - X in this report.

The values were:

$$C_{X_{\infty}} = 1.223$$
; $C_{T_{\infty}} = 1.290$; $C_{\lambda_{\infty}} = 1.171$
 $k_{X} = -20.692$; $k_{T} = 0$; $k_{\lambda} = -17.889$

The observed and fitted ballistic coefficients are compared in Tables 1, 2 and 3 of Appendix D. The relations between the fitted ballistic coefficients and the altitude of release are shown in Plots I, II and III in Appendix D. The fitting provides for obtaining the ballistic coefficient for any altitude of release. The actual points on the plots in Appendix D are shown by dots and their probable errors by horizontal strokes placed on the sides of the dots. The computed C: Y relations are shown by heavy lines. The dotted lines furnish the probable error of forecast. The band included by these lines is determined by addition and subtraction of the probable error of the computed C: Y relation from the curve.

The construction of the table of DS followed general instructions given in file 00 063.2/4524 (Confidential). The trail angles, times of flight and dropping angles tabulated were obtained by interpolation with the fitted C: Y relations in the Bomb Ballistic Auxiliary Tables (Provisional) computed in the Ballistic Research Laboratory. These tables give trail angles, times of flight and dropping angles as functions of the altitude of release, Y, the calibrated indicated air speed, V, or true ground speed, $V_{\rm g}$, and the reciprocal ballistic coeffi-

cient, $\frac{1}{C}$. The intervals of the arguments used in the Bomb Ballistic Auxiliary Tables are the same as those used in the present series of abridged bombing tables. The small differences between the observed mean standard ranges, times of flight and trails and those elements which would result from employment of these tables are shown by the columns $X-X_f$, $T-T_f$ and $\lambda-\lambda_f$ given in Tables 1, 2 and 3 of Appendix D. These differences are compared with the probable errors of the observed mean standard elements in Plots IV, V and VI of Appendix D. The importance of employment of the fitted C_X : Y, C_T : Y and C_X : Y curves is shown by the small magnitudes of these differences.

The bombing tables BT-100-B-3 are a revision of bombing tables BT-100-B-2. The ranges of arguments included in these bombing tables are indicated in the table below:

Element		eed /hr.	Altit ft	1
PTeme110	Mini- mum	Maxi- mum	Mini- mum	Maxi- mum
Trail Angle (Calibrated Indicated Air Speed)	100	250	1800	35000
(Calibrated Indicated Air Speed)	580 300 16	 	1800 1800	21000 31000
Time of Flight (Calibrated Indicated Air Speed)	16	0	1000	35000
Dropping Angle (Ground Speed)	100	250	100	10000

The Introduction to the bombing tables BT-100-B-3 has been shortened to one page and contains only the most essential information.

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Appendix A
Mechanical Constants of Bombs

Appendix A
Mechanical Constants of Bombs

Maria	rechar.	IICAI COIIS	tants of bomi	· · · · · · · · · · · · · · · · · · ·	**************************************
		m	x	$\mathtt{I}_{\mathbf{L}}$	I _T
Program, Group, Serial Number	Date of Release, Run Number	Weight Complete as Dropped	Distance of Center of Gravity From Nose	Longi-	Moment of Inertia About Transverse Axis Through
			·	tudinal Axis	Center of Gravity
		lb.	in.	lb.ft. ²	lb.ft. ²
KS-138L-9 8 12 10 11 7 KS-138-13 18 14 17 16 19 20 22 23 24 26 31 37 32 28 36 33 37 38 39 40	2 3 4 5 6 3/21/38-1 2 3 4 4/25/38-1 2 4/28/38-1 3 4 5 6 1 2 3 4 5 1 2 3 4 5 1 2 3 4 5 1 2 3 4 5 1 2 3 4 5 1 2 3 4 5 1 2 3 4 5 1 2 3 4 5 1 2 3 4 5 1 2 3 4 5 1 2 3 4 5 1 2 3 3 4 5 5 1 2 3 3 4 5 5 5 1 2 3 3 4 5 5 5 1 2 3 3 4 5 5 5 3 5 3 5 5 3 5 3 8 5 3 5 5 5 3 5 3	99 99 99 99 99 99 99 99 99 99 99 99 99	17.75 17.87 17.87 17.87 17.87 18.00 17.81 17.75 18.25 18.12 17.94 18.37 18.37 18.37 17.87 18.37 17.87 18.25 18.12 18.37 17.87	5.438480 5.438480 5.438480 5.438480 5.438480 5.438480 5.438480 5.438480 5.438480 5.438480 5.438480 5.438480 5.438480 5.438480 5.55555 5.555555555555555555555555555	75.24 73.78 74.36 75.06 74.99 73.82 76.12 76.12 76.53 74.96 75.30 76.39 76.39 76.48 76.58 76.68 76.68
40 41 42 43 44 49 43 55 55 51	3 4 5 6 5/6/381 2 3 4 5/25/38-1 2 3 4 5	99 99 99 99 99 99 99 99	17.94 18.06 17.87 18.00 18.50 18.22 18.00 18.45 18.60 18.55 18.60 18.40	5.406 5.395 5.395 5.3748 5.548 5.548 5.429 5.429 5.429 5.395	78.12 75.98 76.85 75.55 75.72 75.80 76.82 75.35 74.27 74.20 75.48 74.39

Appendix A (Cont'd)

Mechanical Constants of Bombs

,	Mechanical		0 01 2011100		
		m	. / x	$\mathtt{I}_{\mathbf{L}}$	$\mathtt{I}_{\mathtt{T}}$
Program, Group, Serial Number	Date of Release, Run Number	Weight Complete as Dropped	Distance of Center of Gravity From Nose	About	
		1b.	in.	lb.ft. ²	lb.ft.2
112 109 110 111 102 103 104 105 106	345 12345 12345 12345 12345 12345 12345 6789 105/4/3912345 6789	100.8 99.5 100.0 99.8 98.5 99.8 99.9 99.5 100.1 99.5 100.2 100.4 99.5 98.0	18.32 18.43 18.50 18.57 18		76.39 77.47 78.47 78.49 78.66 77.19 78.66 77.78.36 77.83 77.89 77.89 77.89 77.89 77.89 77.69 77.69 77.79

Appendix A (Contid)

Mechanical Constants of Bombs

Program, Group, Serial Number	Date of Release, Run Number	m Weight Complete as Dropped	x Distance of Center of Gravity From Nose in:	I _T Moment of Inertia About Transverse Axis Through Center of Gravity lb.ft. ²
KS-138-1 2 3 4 5 6 7 8 9 10 1 2 4 5 7 8 9	7/11/39-1 2 3 4 5 6 7 7/17/39-1 2 6/21/40-1 2 4 5 7/5/40-2 3 4 5	99.0 99.0 99.5 99.5 98.5 99.5 101.0 102.0 102.0 101.0 101.0 101.0 101.0 101.0 100.0 99.0 100.0	18.25 98.07 18.14 18.00 18.25 18.14 18.25 18.27 18.10 18.08 18.03 17.91 18.14 17.86 18.01 18.16 18.16 18.18	74.73 75.33 74.57 75.35 74.45 74.96 75.43 75.90 76.28 72.64 75.75 75.48 75.91 74.87 75.39 75.62 75.42

Appendix B

Primary Results of Range Bombing

MARCH 9,1938 ... 100 LB. PRACTICE BOMB M38A2 ... AIRPLANE BIS

PILOT: CAPT. D. W. WATKINS (1-4), W. O. J. A. LEE (586) SOMBARDIER: CAPT. C. S. THORE

SKY		3/4		AIR.	THE S		1	RAIL A	AND D.	S. BAS	ED O	N C	1.
	TIME	ALTI	TUDE	A)	A SPEE	D	GRINO.	CLIMB	- GLIDE	- market de sobre	A STATE OF THE PARTY OF THE PAR	AL ALLEGAN	OFFICE OFFICE OFFI
BOMB	OF	AIR	GRIND	CAL	TR	and the same of the same	SPEED	A AM	GR'ND.	RA	NGE .	DEF	LEC
NO.	REL.	085	088	IND	AIR OBS.	GRND.	08S.	CBS	085	OVER	SHORT	RIGH	TI
To the second		FT	FT	MAHA	M/HR.	MAR	MAR	FTMIN	FT/MIN.	Ft	FT.	FT	
	11:05	8810	8800	146	167.3	163.9	105.7		+ 6.6	309	-	13	A Secretario
. 2	11:05	8810	8800	146.	167.3	163.9	105.7		+ 6.6	318	AL A.	100	
3	11:15	8840	8813	145	166.2	160.7	102.3	10000	-81.6	270	P. A.	84	
4	11:25	8810	877.3	144	164.9	161.7	103.7		-73.8	204		27	
5	11:35	8800	8769	148	169.5	167.0	108.4	1000	-75.6	144			T
6	11:45	8850	8843	148	169.8	165.1	106.8		-63.6	369		.30	
	-	-	of any have stiff great expectly	-		CE	NTER	OF THE	ACT	269		4	
							MEAN.	DEVIAL	CHRIS	6	3		43
	411		A CONTRACTOR OF THE PERSON NAMED IN	THE		9:51		1:35		CORRE	CTIONS	USE	0 1
The state of			ELOGIT					13.0	MILS	IN '	RANG	E	DE
WIND			E; VEL			56.		93.7	and the specimen with the	10		-	-
	BAL	LISTIC	MEAL	OCITY NUTH (TO)	298.	The state of the s	289.0°		***	+25	.0	0.
near		SURF				1.061		.046	DENS	ITY		in the	-
UMNSY	1.7 4.00	LLIST)	C (SUR	FACE)		1.04	25 to 10 10 10 10 10 10 10 10 10 10 10 10 10	.037	101	AL.	+25	0	0.
101		-		To the same			- vanisher in a	.032	-				-
		SHIM	NO	TEL AN	ERROA	EOUS	RANGE	WIND C	ELL		6		The state of
		2			O MILS		SIVEN	HE					
		15											
			1								0		
		9	(3)).t.	3	
		3/1	1										
	147.1	13/	ATH								4		
		1 4		A									T
			X										
			OH:										
		THE	-423 3 64-		this						343		1
			10 10		19、10年等日本共产品			WHILE!	A Park	DR.		BIT	-
							10 11	41		TARK	ET		
The state of the s	EGEND ACT	7 1	PACTE	TOA	ANGLE		20104					-71	
		JAL- QE	PACTS (OF IMPA	CT	CORRE	CIEDI						-
at with	The state of the	2 Part	and the last			150 24	100	1000	The state of the		Total Control	Soft 15	1

MARCH 9,1938' NOOLB. PRACTICE BOMB M38A2 AMPLANE BIB

		OT GA	PT. D. W.	WATKI	NS (1-4		The state of the s		RAIL A				Maria Company		
1			ALTI	TUDE	ĀI	R SPEE	and the second second second second	prince processes	question in the same	The second second	Agent representation or extension	a direct and a second production of the party of	And in constitution of the last of	TARGET	
-	BOMB		I AIR	GR'NO	CAL:	TR	UE	SPEED	AIR	GRIND	RAI	NGE	DEFLE	ECTION	
	NO.	OF	CBS.	083	IND.	AIR OBS	GR'NO.	GR'ND	085.	085	OVER	SHORT	RIGHT.	LEFT	
		REL.	FT.	FT	MAHR		M/HR		FTMIN	ET/MIN.	FT.	FT.	FT.	FT	1
-	. 1	11:05	8810	8800	146	167.3	-	105.7		+ 6.6	54		THE	24	1
	2	11:05	8810	8800	146	167:3	163.9	105.7		+ 6.6	63			48	
	3	11:15			145	166.2	160.7	102.3		-81.6	12		84	· · · · · ·	
1	4	11:25	- Section Section -	and the second second second	144	164.9	161.7	103.7		-73.8	Angles and the second	48	. 27	MAG	1
	5	11:35	-	8769	148	169.5	167.0	108.4	-	-75.6 -63.6	of an exist of recipitation in	114	30	45	1
1		111.43	1 0030	0043	140	103.0	Carlo modernant to a	after the spirit in the sales of the	OF IMP	dissipative are varies	13		4		
		-		-		7	-		DEVIAT		Bearing	3	-	43	
	MA TAKE	A.V.	The second second second		TIME	*	9:5	1	1:35		CORRE	CTIONS	USED		1
	-		RFACE,			M/HRI	the state of the state of		13.0	MILS	5 181	RANG	E	DEFL	1
-	WIN	U	ALTITU	19 Custo	OCITY.		56 49		93.7	WI WI	ND	_	-		
		AS	LLISTIC	TAZI	MUTH ((TO)	298		289.0°		-				1
	ricras	SITY TI	AT SURF		PACEL		1.06		1.046	DEN	SITY			74	
	DEN		BALLIST				1.04		1.032	ТО	TAL	-		-	1
		1				NOTE	SECINT.	6 600	RECTED	FOR F	ANGE	WIND C	F -4		
		1	1	2	-	144	MILS A	ND THE	ERRO	NEOUS .	RANGE	MIND (F		1
			1	1			-25.0-1	MILS GI	VEN-TH	E-BOM	BARDIE	R			20
			1	EN.		1		1			1		10-21		
			1	A LEIS			70 11	2			1				1
	-		1	1/8/1/A								6			1
			1	B/119	1	-					Ti Man		134		10
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	*		141	E	1	7						¢.I.	3	FE	1
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			Alle,	TO TO		To the second		age of			F	4	1	DER SER	
	THE S			N N	IGH I	To local	Part I			79.13			26 3	DISIO	
			1	CTIC					1818					10010	
1	7		Train.	DIRE	Service de la como		3.73		141.7		9	13.1	1873		10
107	1 12			10		1:1							1	1	1
			1-1-			1		Hi						++-	1
24	23 -	1	1	-	N asherman	SEND.			No.		-	Tali:	138	1	1
			1	-	Address to Delper marger	CORREC	ALTERNATION - THE			1		-	12		20
24		1		-	-	CENTER	OF IM	AUT.		-	1.1.			+ 44	1
		1	1:15	Li	Lil		Litte	L.L.	adjuly and the state of	LECTIC	- An or the second second	the sample and	1	1	1
43	200	1		2 1	11		*			00 1	T.	0 1	RT.	100	

100 LB PRACTICE BOMB M38A2

AIRPLANE BIB

	PILC)T- W. (D. J. A.	LEE.	AID:	Pro to			***	BOMBAI	RDIER.	CAPT. C	S. THO	DRPE	
			ALTI	TUDE	Contraction of the second	R SPE	0	GRND	CLIMB	- GLIDE	S. BAS	TIONS F	POM T	I.41	1
3	вомв	TIME	AIR	GRND	may been my	TR	a decreased disign	SPEED	AIR	provide disciplination as	RAI		minimum marine	CTION	+
	NO.	REL.	085	OBS.	IND	AR.	GRND.	GR'ND	085	oas.	free house and the same	SHORT	to the sill and the sales and the	-	1
		ncc.	FT.	FT	M/HR				FT/MIN.	FT/MIN.		FT	ET.	FI	
	1	10:50	9200	Commence of the land on	140.7	Antonios brodesignes	And the second	135.7	Continued of the state of the s	-196.2	54			123	
	3	11:00	- Cappaign against the copy on the copy	9261	Children on Tonking or and	mare house an enter	165.4			-227.4	- and other the sand of the		- Andrews	234	
	4	marine matter statement	-	9255	144.0	STREET, STREET		142.6	the Branch and something	- 85.2 - 31.2	117	15	1 68	270	
	5		9160		The second second	162.4		.00.5	TANK T	31.2	30	15	-	339	
**	6	12:00	9180	9236	140.7	162.4	158.7	135.4		+ 10.2		186	-	57	1
19.	PAI	NGE: -	C BAL	LISTIC	WIND ROSS:	M/HR	GE GE	INTER	OF IMPA			and and policy or	0.5	200	
				Andrew Co.	TIME	And the second of the second	9:36	A committee that would have been	DEVIATI	TO THE WORLD STREET	7	ment and the second	-	1-2	
1		SUR	FACE: V	ELOCIT				per confidence	Charles of the designation of the Co.	Conditions of the same	-	TIONS	man si fate man	-	
	WIND	- 1AI 1	al Hill	IE, . EL	COLLA	A.	29.6	50 40	6.6	-	IN		-	EFL.	
1		BAL	LISTIC	AZIN	MUTH (TO)	23.0		15.8 07.1°	Will	40	-3.0		2.OR	
	ÓFNO!	TY JAT	SURFA	C (SUR	gares.		1.00		995	DENS	YTE	-		-	
4				C (AIR			0.99		990	To	TAL	-3.0		2.0 R	
			屋		1										
			13	10/			* 1 - 1								1
		1	STIC	\$/			13							S	
			4/1/11	3/											100
			01/18	USES.											100
*				1/		5		-9	100		3-15			ET	+
			X			0	A 1.1.	0	1.			TAD		FE	
			14						1			TARC	, ,	Z	0
		- 1					1		04	444				DISPERSION IN	
-			DIRECTION	5 -										ER	
-	井井		EC	1	7 10									DISF	
1			- 6	5	144										100
1											2 7.3	Series 1			
-	++++	1	EGEND												
1	4	-1-16	ACTU	IAL CEN	ACTS (T	RAIL A	NGLE C	ORREC	TED)		6				
a Line			A-CENT	ER OF	IMPACE	CORRE	CTED	OR-DE	FLECTIO)N	. 0				200
-			+ 1			44									
-	et (C										-				
1		1 - H		4	11-1							THE STATE			
L			runt	ilil		300		1	DEFL	EGTION	with a spillproper regard	Million Malay w. may as I have	in last		
N. A.	The South			1		301	41	20	10	100	LT.	. 0	00. RT	10	0

APRIL 25, 1938

IOO LB. PRACTICE BOMB M38A2

AIRPLANE BIB

19. 43 44		T. D. W.	WATKIN	the service of the se			7				TE WELL			
17.	TIME	ALTI	TUDE !	Al	-	ner harden staffensen	1	-	-	-	at me management	1	-	-
BOMB	OF	AIR	GRND	CAL	Section of the last of the las		1 100	1 AIR	GRND	-	farmer de la	-		-
NO.	MAR TIME OF OBS. OBS. IND. AIR GFND OBS. OPER SHORT RIGHT LEFT OPER SHORT OBS. OBS. OPER SHORT RIGHT LEFT OPER SHORT OPE		-											
	(1-6-	FT	FT	M/HR			M/HR	FT/MIN	FTMIN	FT	FT.	FT	FT	-
1	10:50	12320	12283	144	173.7	174.7	140.9		+23.4	504			159	-
-	May insultinately element	Approximation of the same	And the second second second	apriliance responsed	A CONTRACTOR OF THE PARTY OF TH	Subsensite someone	and relative to the real place becomes	- British Contract of the State of	- donient of the same	de retre to representation		-	and the same of the same of	1
-	- maringarana	A	-	for the same and the	in decidence in the	-	- Print married and	Spine a printer street	-	-	-	42	-	- marin
manage man	Company of the section of the section	Secretary care threat a water	of graph rections the type of the of	- Bridge and a second	define the stay with me so that	appropriate state office or spirit said	- warmen	the springer and the springer	and distribute and an improve a selection	and the same participation of a	of many	37	-	-
-	11:41	12340	12309	145	174.9	170.0	142.2	-	+117.6		96	-	66	1
	COENT	141 94	LLISTI	MINI	- M/	-	TUTEO	05 100	107	241		15		-
RA	NGF:-	S 7	LLISTA	POSS:	+82		NICH	DEVIAT	ION	241	20	10		-
	THOE.	0.	and the second section of the second	tracing the bright colonies of the bright was	10.6	A STATE OF THE REAL PROPERTY.	AND THE PARTY SHOWS	The state of the s	a transport of the section of the se	AND RESIDENCE OF THE PARTY OF		NCE		7
-	10115			- white the state of the state	** / >		and the same of th	Conference in the segment	-			-		- Ann
100	AT	ALTITU	DE, VEL	OCITY	W. HILL	34.			RAIL	IN	RANG	35	DEFL.	- In
WIND			JVEL	DOITY	11	25.	2	27.3	WI	ND.	-2.7	1	3.0 R	-
100	Total Control		LAZI	AULD (10)		and the last		DEN	SITY	+2.2	,		Bernand
DENSI				(FACE)	w. S				-	and the second s	-			- The
SKY ARITUDE AIR SPEED GRIND, CLIMB—GLIDE DEVIATIONS FROM TARGET BOMB OF OBS. OBS. IND OBS. OBS. IND OBS. OBS. FT. FT M/HR M/HR M/HR M/HR FT/MIN FT/MIN FT, FT. FT FT 1 10:50 (12320) (12283 144 173.7 174.7 190.9 ± 23.4 50.4 159. 2 11:00 12320) (12263 141 169.9 171.5 140.0 ± 52.2 80.1 42 13.3 11:06 (12320) (12263 145 174.9 173.8 143.9 ± 28.2 80.1 42 13.3 11:06 (12320) (1236) (145.174.9 170.0 142.2 ± 117.6 96 66 DIFFERENTIAL BALLISTIC WIND M/HR CENTER OF IMPACT 241 15 RANGE: −5.7 CROSS: +8.2 MEAN DEVIATION 329 112 TIME 10:03 12:35 CORRECTION WED AT ALTITUDE, VELOCITY (M/HR) 34.0 29.5 MIND ALLISTIC (VELOCITY (M/HR) 34.0 29.5 MIND −2.7 3.0 R SURFACE, VELOCITY (M/HR) 34.0 29.5 MIND −2.7 3.0 R OBS. OBS. OBS. OBS. OBS. OBS. OCCRECTION USED OBS. OBS. OF SOVER SHORT RIGHT LEFT TOTAL −0.5 3.0 R DENSITY SALLISTIC (SURFACE) 1.028 1.016 ACTUAL IMPACTS (TRAIL ANGLE CORRECTED) ACTUAL CENTER OF IMPACT, CORRECTED FOR DEFLECTION TARGET 2.2 MIND 1.016 ACTUAL CENTER OF IMPACT, CORRECTED FOR DEFLECTION TARGET 2.2 MIND 1.016 ACTUAL CENTER OF IMPACT, CORRECTED FOR DEFLECTION TARGET 2.2 MIND 1.016 ACTUAL CENTER OF IMPACT, CORRECTED FOR DEFLECTION TARGET 2.2 MIND 1.016 ACTUAL CENTER OF IMPACT, CORRECTED FOR DEFLECTION TARGET 2.2 MIND 1.016 ACTUAL CENTER OF IMPACT, CORRECTED FOR DEFLECTION TARGET 2.2 MIND 1.016 ACTUAL CENTER OF IMPACT, CORRECTED FOR DEFLECTION TARGET 2.2 MIND 1.016 ACTUAL CENTER OF IMPACT. CORRECTED FOR DEFLECTION TARGET 2.2 MIND 1.016 ACTUAL CENTER OF IMPACT. CORRECTED 5.000 MIND 1.016 ACTUAL CENTER OF MIND 1.016			Same											
1					7,1	4444		Con extens						1
N S				-		A CONTRACTOR OF THE PARTY OF TH	100		1	3				1
4	1.15	TELL.	1	54 -				E TOTAL STATE OF THE PARTY OF T		19	1371	-		- Therese
	To the second		1.12							-	1 111	133		See August
1	1	-	3/-/3	4		1						-		-
		Market !	12/	2			The last					1.53		Chain
	1		2	15	1		-		3 3 3 3 3 3 3 3 3 3 3 3 3 3 3 3 3 3 3 3	1 3 1	1-11-	1		The same
1			3	1/2	A	1	117 11	240		4				Section 1
100000		THE STATE OF		11/		THE STATE OF	E The		4.1.			1	1 - 1	1
1	1.7.721			1	SURFAC		101 30		131/2	111	114 1-11			
			P	(1	100	WIND	1		11/3				Z	-
				N I			h	1					- No	5
		434		1.()	11 1	1			1			141	I BS	211
	Mark Control			3					W W	1 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2	1			2
第一位				00	111111		法域	-	130	C.I.	1 - 1 1 - 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1	13th	, 0	Towns.
122					The East	1-11-	1 3	TIEV		04		1		Account to
-	-						1 1 2	12.	1000	1		1		marin ales
16 800	TIME ALTITUDE AR SPEED SRND, CLIMB-GLIDE DEVIATIONS FROM TARGET OF GRND OF ORS. IND. AIR GRND OSS. ORS. ORS. ORS. ORS. ORS. ORS. ORS.													
	ACTUAL	INDAC	TO ITO	IL ABIC	TE COD	ALTERNATION OF THE PARTY OF THE						The second second	C . W	400
	100 4 5	1 - 2 - 3	1 - 1 - 1	1	LE COF	RECIE	91					11		+
0	ACTUAL	CENT	ER OF	MPACT	1	1								Annual Land

APRIL 28, 1938

100 LB. PRACTICE BOMB M38A2

DEFLECTION IN FEET

100

PILO	TO SELECTION	L.H. T	ULL	AIR		14.1			NO D.		ED ON			
* *	TIME	ALTI	TUDE	All	R SPEE	Ó		CLIMB	- GLIDE	DEVIAT	IONS F	ROM	TARGET	
BOMB	OF	AIR	GR'ND	CAL.	TR		SPEED GRIND	AIB.	GRIND	RAN	IGE	DEFL	ECTION	
NO.	REL	OBS.	085.	IND.		GR'ND	OBS.	085	085.	OVER	SHORT	RIGHT	LEFT	
	MEL	FT	FT	M/HR			M/HR.	FT/MIN.	ET/MIN	FT	FT	FT.	FT	
1.	10:55	6270	6162	140	153.7	148.6	143.2		+ 27.6		54	129		
2		6270		141				100		30	-		- 12	1
3	11:25	-		143	157.6	Personal Property and	Section of spinsters and or said	Autoria - contractor	- 67.2	105	175	15	- 60	+
4	11:33	6270	6349	140	154.3	policy larger and the control	150.1	and the same	+143.4	-	135	120	60	1
5	market and a stand		because or an order	148	Consideration and Appropriate	and the supplemental and the	Lane and the same of	fam. wante	+110.4		7 17	90		+
Andrew Commercial Comm	A management and a	white or the last section where	the second or the second	WIND	Majorganica para tito carj	armen areas and the second	the company was a second property		demande inglêtie de	7		47	-	1
publication parties or described to the parties of	NGE:-	the property of the special		ROSS:						6	8		66	7
	Contract of the Contract of th			TIME .		9:38	3 1	2:00	1 19 10	CORRE	CTIONS	USED	To be	10
				Y (14.0	MILS	IN	RANG	E	DEF	1
WIND	AT	ALTITU	DE, VEL	OCITY	N.	9.		3.3	WI	-	-0.		O.I R	7
	TAC	LISTIC	AZI	OCITY (TO)	306.		261.3°					2 2 34	-
						0.99		0.984	DEN	SITY	+0.			-
DENSI			IC (SUE	OBS.		0.98		0.992	ТО	TAL	-0.2	2	0.1 R	1
			FILE					I Was	1				1-41.	7
								1 21						1
							1 19 1							
			+						1.1	11/19/			1	-
	E I		1 4							-		1		-
			12	1					14	3				-
	Fig.		200	1						0				-
		*	Total Control	/				1 1/2 3	1		6	1		-1
	ay II.	1111	01	1		MAIN!					ri			FEET
		ACE WIT	F	1/0		7			2	1	1.	2.5		1
	SURT	1	FLIGHT	1 B			THE.					-	15	Z
	1		99	10	Red in	13/10	MIN		TAG	GET	1311			DISPERSION
1				1 101		100	131				1			ER
12			1 OF	BALL									9	SIC
-			DIRECTION	18			133	t. Hi		1		tint:	11:17	-
		-	مَ					-			1-1-	-	1	-
			1 A		La Line	-1-	14.	4	1		1	-		-61
	LEGENE				12-14		1 3 14					-		-
	And the second	UAL IN		TRAIL		CORRE	TED)-			11		111	Pil	1
	O ACT	UAL CI	ENTER	OF IMPA	CT		1 14			1 1 1 1	3 4 1 77		-	
	121	1	2.4	1 10 mm - 11	10000		1 6 10-0	+	4	Total Park	1	Par is t		- 1

MAY 2,1938

SKY			LEE'	AIR:			-	RAIL A	NO D.	NOIER: C	ED ON	1 C =	1.60	7
	TIME:	ALTI	TUDE	-	R SPEE		GRND.		-				TARGET	4
Вомв	OF	AIR	GR'ND.	CAL.	TRI		GRIND	AIR	GRND	RAN	GE	DEFL	ECTION	1
No.	100	085	085	IND	AIR OBS	GR'ND.	OBS.	085	088	OVER	SHORT	RIGHT	LEFT	1
	REL.	FT	FT	M/HR		M/HR	M/HR	FT/MIN.	FT/MIN	FI	FT.	FT	FT	-
1	11:26	15690	15585	134	170.4	170.0	121.9	The transmission of transmission and the	+190.8	proproduction at the same	291	12	-	1
2		15730	Account to the same	134	170.4	The same artists of the same of	124.3		- 8.4	33		84	a track	1
3	discourse months	15710	distribution to the second	135	171.7	174.3	124.8	T. 12171. 1 21	+ 58.8		117	60		1
1.4	of transmission	15700	place are not well to have seen	136	172.9	COMMENT OF THE PARTY OF THE PAR	126.1		+119.4		219		135	1
5	12:11	15720	15561	138	175.4	178.2	128.3		-236.4	99			117	1
6	TAU SES		*********		1 1 1 1 1	-		-	1 24	****				1
DIFF	ERENT	IAL BA	LLISTI	C WIN	D M/H	R. C	ENTER	OF IMP	ACT		99		19	1
distribution for the same	NGE:-	the same of the same striple in	and the second second second	ROSS:	proposition of a second		MEAN	AND DESCRIPTION OF THE PERSON	The same and the second	13	32		85	1
		The same of		TIME		9:50	0 1	2:45	The second second	CORRE	CTIONS	USE)	Britan
	1 SHE	FACE A	ELOCK	CONTRACTOR OF STREET	M/HR)	-	or region of section appears	14.0	-	-	-	and the same of the same	DEFL.	-
A111625	TAT		DE, YEL		" runs	48.		51.3	POR S	SIN	MAN	20	UEFG.	-
WIND		LISTIC	. [VEL	OCITY	170	37.		37.9	W WI	ND	-4.7	7	2.3 L	-
	2 4 7		Luci	MUTH (10)	321.	The state of	3192°	DEN	SITY	-0.2	2	-	-
DENS		T SURF	ACE IO (SUE	FACEN		0.99		0.985	-					-
DEMO			IG LAIR			0.97		0.967	ТО	TAL	-4.9)	2.3 L	1
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100 LT.

MAY 3, 1938

100 LB. PRACTICE BOMB M38A2

AIRPLANE BIS

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2000	TIME		TUDE		R'SPE		GRND.	-	- GLIDE					-
BOMB	OF	AiR	GR'ND	CAL	AIR	GR'ND.	GRIND	Ain		RAN	,		ECTION	1
NO.	REL.	OBS	OBS.	IND	OBS.	085.	.085.	150	085.	1 1 1 1	SHORT	1 .	1 3700	-
		FT	FT.	M/HR	-	M/HR	Comments.	LAMIN	FT/MIN.	Les Housestreet Continues	FT.	FT	F7.	1
2	11:15	-	15655	133	171.9	172.3	130.2	-	- 24.0	-	132	96	75	-
3	11:32	a deposit from the same	15598	133	169.2	magnitude of the street of the street,	131.5	-	-162.6	The state of the state of the state of	327	27.65	360	1
4:	11:41	- opposite the desire	15688	136	173.3	sufference come from the	128.3		- 22.8		156	357		1
.5	11:48	15700	15634	Santa contractor	171.9	· ·	131.0	in the constitution of the	- 61.8	-	312	237		- Property
6	11:55	have been and	15661	demandant prices	the family was a second	174.1	132.1	A	- 64.2		147	426	-	1
	and the same of the same of the same of	Commission of the same of the	LLISTIC	ROSS:	and our more representative	R. C		DE VIAT			194	114	27	-
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WIND	AT	ALTITU	DE, VEL	OCITY	'n'	38.	3 -	45.3	-	3 IN	RANC		DEFL.	-
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MAY 6, 1938

100 LB. PRACTICE BOMB M38A2

and the second		ALTI	TUDE	AIR:	R'SPEE	-D		I	and the inter-state or since person	Annual Section	SED OF		Separate of the Separate Separ
BOMB	TIME.	AIB	GRIND	CAL	-		SPEED	francisco of reco	-	-	TIONS E	gaples - service	
1	OF		1.3		AIR	GR'ND.	GRND	AIR	GRND.	-	NGE	DEFLE	·
NO.	REL.	085.	083	TNO.	085.	085.	088,	The Contract of the	Mar 1 - TH	A CONTRACTOR OF	SHORT	RIGHT	LEF
		FT	FT	M/HR.	-	M. HR.	M/HR	FTMIN	FT/MIN.	FT.	FT.	FL	FT
1	11:45	political in the restaurant names	12523	134	162.1	160.6	134.4	-	- 1.8		150		321
2	where the same of a laborate	12520	See marketing const.	132	159.7	154.0	123.4		+ 2.4	-	120		57
4	Charles Britishelman - a	12570	Berginson or spanging or would	133	161.1	155.4	121.1		+ 44.4	-	Million State		603
5	DESCRIPTION OF THE PARTY OF	of the engine square	12489	135	162.1	157.5	126.0		-105.0	to known the state of	111	228	
6	16.60	12020	12403	133	103.4	163.6	133.2		+ 44.4	-	111	288	-
	ERENT	IAL BA	LLISTI	C WINE	MZu	C 5	NTED	OF MAD	ACT		00		0.7
RA	NGE: -	1.7		ROSS:			ALTERNATION OF THE PERSON OF T	DEVIATI	sections come includes a gain relieful	three spendit tennight which	80	20	93
h	-		Sent of the sent o	TIME		9:53	The same of the same of	1:04	-	-	CTIONS	And the second s	
			ELOCIT	Y (M/HR)	17.	0	14.0	The same and the second	IN	RANG	-	EFL.
WIND			E, VEL	OCITY'	"	35. 31.	0	34.1			70.8		1.9 R
The Live	V. Profile	S	- LALIN	JUTH (10)	272.	5.00	284.6°	DEN	SITY	h		* *************************************
DENSI		SURFI	C (SUR	FACE)		0.96		0.968			-1.6		-
			G (AIR			0.96	THE PARTY OF	0.968	רסד	TAL.	-2.4	4	1.9 R
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	EGEND			- 12 T				p High					
	COLVIE		Carlot State of the State of th										

200 LT

RT. 200

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MAY 25, 1938 100 LB. PRACTICE BOMB M38A2

AIRPLANE BIB

	TIME	ALII	TUDE	Ai	R SPEE	0		CLIMB	- GLIDE	DEVIAT	TIONS F	ROM	TARGET
BOMB	OF	AIR	GR'ND.	CAL.	TR		SPEED	AIR	GRND	RAI	NGE	DEFLE	CTION
NO.	REL.	085.	085.	IND.	AIR OBS.	GR'ND.	085	OBS.	085.	OVER	SHORT	RIGHT	LEFT
	1	FT.	FT	M/HR	M/HR		MAR	FT/MIN.	FT/MIN.	FT.	FT.	FT	FT
1.	11:36	6180	6176	143	157.2	155.4	155.7	Providence and the second	+ 25.8		21	UI	1
2	11:50	6160	6156	141	154.8	151.5	151.6		+ 6.0	39			105
3	12:02	6160	6167	141	154.8	154.2	154.5		+ 37.8		33	51	
4	12:10	6150	6130	142	155.9	155.0	155.7	-	- 1.2	87		45	
5	12:15	6110	6057	143	156.7	157.4	158.0		+124.8	3		147	
8 1					34				-				
DAI	NGE: -	AL BA	LLISTIC	WINE	M/H	R. CE	NTER	OF IMP	ACT	15		50	
RAI	NGE.		Service and complete and the service and	A CAMPAGE AND A STATE OF THE PARTY OF THE PA	-3.8	The same of the sa	The second	-	The sales and second	3	of our being	(4
the state of the state of	-	5° 11. 24. 24.	and the second second	TIME	NA /	10:32	1120 1230	2:39	1	CORREC	TIONS	USED	
-	- 1 AT - 1	MATITUE, V	ELUCIT	OCITY	M/HR)			6.0	MILS	IN	RANG	E	EFL
WIND		LISTIC	SVEL	OCITY	43	1.	5	1.1	WI	ND ON	-0.7		4 LT.
				AUTH ((10)	12.	THE RESERVE TO	79.4°	Page 440	TY		-	
DENSI		SURF		FACE)		1:00		.992	FICTOR	214 T	T Z.4		
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11:1	1246 126	4 - 4 - 4	The state of the s	TER O	F IMPAC	T				7-1-1			3.
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1000													

LT.

RT.

OCT. 31, 1938 100 LB. PRACTICE BOMB - M38 A2 PILOT: CAPT. D.W. WATKINS

6	SKY			1			AIK	1	AIR:						1 4	16 4	IL A		MBA O.									
	V-100	TI	ME	-	ALT	-	JOE	min		AIR	SPI	EEC)			-	OR OR		100	08	EVIA	TIO	NS	FRO	M	TAR	GET	7
BOA	MB	363	F		AIR	10	SR'N	0.	CAL			RU		1	PEE	0	1100	1	IOR.		RA	NGE		D	ÈFL	ECT	ION	
N	0.	RE	2	2	BS		085		IND.		AIR		GR'NI OBS	2.3	R'NE	1 3	R'ND	RA	NGE	0	VER	SH	IORT	TRI	GHT	Tu	EFT	1
					FT.	1	FT.	h	1/HF		A/HF					-	MIN	1	FT.	1	FT.	1	FT.	1	FT.	1	-T.	1
1		10:	37	7	080	0 7	7058	- Charles	166	-	85.6	morphon.	84.5	- Property	1.8	-	73.2	-	959	form	32	+	-	-	84	+		1
2	-	10:	-	Brienn	-	majima	069	- dimin	164	1	83.4	4 1	80.9	0 16	8.5	niet Lighting weeks	48.2	oforemen	379	-	84		102	+	-	1	15	1
- 3	Marine Co.	10:	-	-	-	mignes.	7074	margaren	165	ere from	84.5	recipion o	80.3	3 16	7.3	1-1	32.5	41	365		60				. 9			The
5	-	11:1	-	-	and the said	mine	035	-	166	min for inco	85.5	-	82.8	mingeria	and the same	Holomon	35.8	friends	978	- Granton	05						51	1
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	-						Talanton .			ADMI		of parties		3/18	EAN	DE	VIAT	ION			3	33		1		10		1
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	WIN			AT	AL	TIT	UDE					1		3	1	16.			MILS	. 1	N	R	ANO	35		DEF	L.	-
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AIRPLANE B-4A OCT. 31, 1938 100 LB. PRACTICE BOMB - M38A2 PILOT: W.O. J.A. LEE BOMBARDIER: SGT. S.C. SMINK SKY: AIR: TRAIL AND DS BASED ON C = 2.019 ALTITUDE GR'ND CLIMB AIR SPEED DEVIATIONS FROM TARGET TIME OR. HOR. SPEED BOMB GR'ND SIR STATE OF THE PARTY TRUE RANGE DEFLECTION GLIDE GRIND RANGE OF GRNO AIR GR'ND. OBS. OBS. IND. "NO." OVER SHORT RIGHT oas. LEFT OBS. OPS. REL. CBS. FT FT M/HR M/HR M/HA M/HR FT/MIN FT. FT: FI FT 10:53 7120 6970 79 88.2 74.7 + 87.7 2183 88.5 15 30 11:03 7200 6989 2 82 91.6 90.5 76.6 + 46.8 2258 69 18 3 11:18 7180 6926 78 87.0 88.6 76.0 - 37.9 2230 93 12 4 11:26 7120 6922 80 89.2 87.4 73.5 -271.8 2197 96 105 11:33 7080 6907 5 82 91.5 90.2 77.4 2259 39 15 6 CENTER OF IMPACT 62 18 MEAN DEVIATION 28 36 TIME 9:22 A.M. 12:52 P.M. CORRECTIONS USED . SURFACE 15.0 7.0 MILS IN RANGE DEFL. WIND AT ALTITUDE 20.3 16.8 VELOCITY & BALLISTIC 20.7 16.0 M.P.H. DIFFERENTIAL TRANGE WIND +0.3 +1.0 O.ILT. -0.7 BALLISTIC CROSS -0.4 -0.3 DENSITY +2.5 TAT SURFACE 1.050 1.031 DENSITY (BALLISTIC (SURFACE) 1.044 1.029 TOTAL +2.8 BALLISTIC (AIR OBS.) O.ILT. 1. 023 1.019 I tt. 100 0 w uf W Z ARGET 0 0 in a O 0 w T. 00 O C.1 S 0 0 3 100 LEGEND ACTUAL IMPACTS (TRAIL ANGLE CORRECTED) ACTUAL CENTER OF IMPACTS

DEFLECTION IN FEET

RT.

100

100 LT.

PRIOT CAPT. DW. WATKINS SKY: AIR: AIR: ATTIVUDE AIR SPEED CRIND CORD OR OR OR OR OR OR OR OR OR	NOV	/10,1	93 PT	8 . D.	W. 1	WAT	KIN	OL	8. F	RA	CT	ICE	. В	OM	3 —	ME	38 A	2 30Mi	BAF	IDIEF	R: C/	AIF	C.S	ANE	HOR	-18 PE		京本と かい
MAIN ALTITUDE AIR SPEED CRND CLIMB OPE O									12.50	45.		1-10	4		TR	AIL	AA	10	o.s.	84	SET	0 0	N	C=	2.0	19	-	
DAME	1	-	-	Al	TIT	UDI			Al	9 5	PEE	0	1	GR'I	40 H	GLIA	BN		27	Section of the second	-						T	105
NO. REL. CBS. OBS. IND. CC GRIND OBS. CBS. CBS. OBS. CBS. CBS. CBS. CBS. CBS. CBS. CBS. C	ONB	TIME	1			mari da i de la	an and	Anna Maria de Cara	- (ay is not appearing	-	an maradi	-	SPE	Ent	OF	1	HO	R	F	IAN	GE	Mary day	DEF	LE	CTIC	IN	
NO. REL: FT. FT. M/HR. M/HR. P/MR. PT. FT. FT. FT. FT. 4. 11:21 71:60 7138 165 184.7 181.2 188.0 +233.3 5524 18 21 2 11:29 71:20 71:12 164 185.5 184.7 181.2 188.0 +233.3 5524 18 21 3 11:46 71:40 71:37 165 184.7 182.9 187.1 - 20.0 5512 12 36. 3 11:53 71:40 71:34 165 184.7 182.9 187.1 - 20.0 5512 12 36. 3 11:53 71:40 71:34 165 184.7 182.6 187.0 +160.0 5511 18 27. 5 12:00 71:40 71:36 185 184.7 152.6 187.0 +160.0 5511 18 27. CENTER OF IMPACT 17 22	6.13	OF	1	A						-	RT	GRI	2. 张 化五元素		10	GR'I	10	RAN	GE	-	-	-	OT		-		-	1
### FT FT #FT #FT #FT #FT FT F		REL								0	5.1	08	SI		3.	OB	5.			444	· ·			135				1
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JULY 11, 1939

D.W. WATKINS

BOMBARDIER: CAPT. C.S. THORPE

AIR:

TRAIL AND D.S. BASED ON C = 1.21

ALTITUDE AIR SPEED GR'ND CLIMB DEVIATIONS FROM TARGET PILOT: CAPT. D.W. WATKINS

BOMB	1	100			000	A	ILTI	rud	E' 7		Al	RS	PE	D		GR'		CLI				DEV	MAT	ION	SF	RON	A TI	ARGE	ET
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GOUNT SEE PLOT NO. 49 A FOR CORRECTIONS AND PLOT OF BOMBS.	, 1	4	1	11:	12	198	50	194	51	12	6	17	1.2	161	.5	121	5.2	+11	4.1	58	19	3	66					29	11
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JULY II, 1939. IOO LB. PRACTICE BOMB M.38A2 BOMBARDIER CAPT. C.S. THORPE PILOT: CAPT. D. W. WATKINS TRAIL AND D.S. BASED ON C=1.21 AIR: GR'ND CLIMB DEVIATIONS FROM TARGET AIR SPEED ALTITUDE OR HOR. TIME SPEED RANGE DEFLECTION TRUE GRIDE RANGE BOMB AIR GR'ND CAL. AIR GR'ND GR'ND OF OVER SHORT RIGHT LEFT IND. OBS. 085. OBS. 085. NO. OBS. | 08S. REL. M/HR M/HR M/HR FT/MIN FT FT. FT. FT. ET. M/HR! FT. 12 315 19850 19429 123 167.1 160.5 129.4 + 32.9 5858 7 3 534 11:53 | 19850 | 19426 | 124 | 168.4 | 163.6 | 126.8 | - 36.3 | 5830 | 3 4 5 6 39 CENTER OF IMPACT 377 118 128 MEAN DEVIATION . CORRECTIONS USED TIME 9:54 12:36 11.0 9.0 SURFACE RANGE DEFL. MILS IN 39.3 47.7 AT ALTITUDE WIND 34.3 32.8 BALLISTIC VELOCITY < WIND . 3.1 R -1.6 -3.1 -12.3 DIFFERENTIAL SRANGE M.P.H. + 5.4 BALLISTIC CROSS 47.0 DENSITY -0.2 0.988 0.996 AT SURFACE ≺BALLISTIC (SURFACE) 1.007 1.002 TOTAL 3.1 R -1.8 BALLISTIC (AIR OBS.) 600 400 A PERSION 0200 3 0 GH 0 BTARGET CORRECTED IMPACTS CENTER OF IMPACT

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JULY 17, 1939. BOMBS NO. 18 2 100 LB. PRACTICE M38A2 AIRPLANE BIBA
BOMBS NO. 3-7 100 LB.DEMOLITION M30
BOMBARDIER: SGT. S.C. SMINK
PILOT: CAPT. D.W. WATKINS & W.O. J. A. LEE
TRAIL AND DS. BASED ON C=1.21

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JULY 17, 1939. BOMBS NO. 18.2 100 LB. PRACTICE M38A2 AIRPLANE B18A
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BOMBARDIER: SGT. S.C. SMINK

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RESULTS OF RANGE BOMBING NO. 61

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RESULTS OF RANGE BOMBING NO.65 JULY 5, 1940 100 LB PRACTICE BOMB M38A2 AIRPLANE 8-17 B PILOT : LT. C. A. PETERSON BOMBARDIER: LIEUT. M.F. SUMMERFELT ÁIR: CLEAR TRAIL AND D.S. BASED ON BT-100-8-2 GR'ND CLIMB . ALTITUDE DEVIATIONS FROM TARGET AIR SPEED TIME SPEED OR HOR. **BOMB** AIR GR'ND CAL TRUE GLIDE RANGE. DEFLECTION AIR GR'ND GR'ND GR'ND RANGE OF NO. OBS OBS IND OVER SHORT RIGHT LEFT REL. OBS. OBS. OBS. OBS. FT. FT. M/HR M/HR M/HR MHRFTMN FT. FT. FT. FT. FT. LOST 25430 163 2 9:46 | 25430 | 24853 163 241.3 240.1 158.3 +189.8 7956 498 15 9:58 |25430|24760 264 177 163 241.0 240.4 153.6 -135.3 7757 4 10:09 25430 24755 228 164 242.4 241.4 267 160.8 - 157.3 7806 5 10:30 25430124777 165 244.0 243.0 162.7 +114.6 7889 61 399 6 CENTER OF IMPACT 122 259 202 MEAN DEVIATION R.O.S. R.O.S. ICAMERA TIME 9.25 10:40 SURFACE

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Appendix C

Individual Standard Elements and Ballistic Coefficients from Reduction of Field Data

Appendix C $^{\mathtt{C}}\mathbf{T}$ \mathbf{T} Y U X λ C_{X} ς_{λ} Standard Standard Standard Standard Standard Program, Date of Time of Trail Group, Release, Altitude True Air Range Flight Run No. Speed Serial Number ft. mi./hr. ft. ft. sec. 160 1.81 KS-138L-8 3/9/38-1 9000 5284 1.76 5277 1.94 12 5302 1.18 1.00 10 5197 25.19 714 1.36 1.43 1.26 11 25.07 669 1.09 5214 5287 25.03 587 1.83 1.12 1.45 KS-138-13 24.71 543 1.64 1.57 3/21/38-1 5256 1.48 1.51 5243 24.74 563 1.57 1.45 18 1.87 5293 14 1.50 17 5251 24.80 569 1.61 1.37 556 1.69 1.53 16 5214 24.59 1.43 14/25/3811 1.28 12000 5925 19 20 22 23 24 31 21 22 32 33 33 33 34 1.37 5956 5977 1.44 1.42 5971 4/28/38-1 20.06 2.07 1.29 1.65 6000 335 4374 1.56 20.10 352 1.94 4363 1.24 1.51. 1.62 20.01 365 1.39 4331 1.46 4305 19.96 380 1.43 1.50 1.57 20.10 352 1.96 1.23 £365 980 1.42 1.45 5/2/38/-1 15000 160 1.47 6651 32.52 1.39 1.43 6637 32.62 1017 1.35 1114 1.29 1.26 6582 32.80 1.24 33.01 1217 1.18 1.13 1.16 45 6530 32.78 1055 1.25 1.34 6637 1.43

			Append	TY C (COUL	, · u)	•			34
Program,	Date of	Y	Ü	X	T	λ	c_{X}	C _T	C _{\lambda}
Group, Serial Number	Release, Run No.	Standard Altitude	Standard True Air Speed	Standard Range	Standard Time of Flight	Standard Trail			
		ft.	mi./hr.	ft.	sec.	ft.	,		
KS-138-38	5/3/381	15000	160	6637	32.87	1077	1.43	1.20	1.31
39	2			6758 6541	32.62	896	1.87	1.35	1.59
40 41	4			6677	32.49 32.82	1084 1024	1.20 1.55	1.44 1.23	1.30 1.38
42 43 35 48	5	, ^		6550	32.59	1097	1.22	1.37	1.28
43	6	7.0000		6651	32.71	1026	1.47	1.29	1.38
35	5/6/381	12000		5959	29.11	873	1.38	1.20	1.29
46	3			6014 6055	29.03 28.99	798 747	1.58 1.77	1.26 1.29	1:42
44 49	4			5974	29.04	841	1.43	1.25	1.52 1.34
46 53	5	4		5986	29.13	850	1.47	1.19	1.33
53	5/25/38-1	6000	,	4297	19.89	371	1.38	1.68	1.49
54 55	2			4372	20.27 19.98	384	2.05	1.01	1.44
52	1 4			4346 4379	20.06	344 330	1.75 2.14	1.45 1.29	1.60 1.68
. 51	5			4336	20.00	357	1.66	1.42	1.55
RX-138-107	10/31/38-1	7000	180	5239	21.69	487	1.69	1.46 1.71	1.58
112 109	-2 3	·		5223 5260	21.57	471	1.59	1.71	1.64
110				5241	21.68 21.60	464 461	1.84 1.70	1.48	1.66 1.67
111	5			5245	21.61	460	1.73	1.61	1.68
102	1		90	2664	21.31	149	1.87	2.28	2.05
103 104	2	·		2681	21.34	136	2.32	2.15	2.25
105				2682 2727	21.64 21.77	174 147	2.35 6.19	1.35 1.16	1.76 2.08
	4	<u> </u>		~ 1 ~ 1	~	-41	U•17	4.10	2.00

Appendix C (Cont'd)

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		Y	ט	Х	T	λ	c_{X}	c _T	c _λ
Program, Group, Serial Number	Date of Release, Run Nó,	Standard Altitude	Standard True Air Speed	Standard Range	Standard Time of Flight	Standard Trail			
		ft.	mi./hr.	ft.	sec.	ft.			
RX-138-106 108 113 114 115 116 117 118 119 120 121 KS-1381 2 3 4 7 6 9 8 10 5 11 12 13	10/31/38-5 11/10/38-1 2 3 4 5 1 2 3 4 5 5/3/391 2 3 4 5 6 7 8 9 10 5/4/391 2 3 4	2000	90 180 90	2671 52679 52265 52265 52265 5226637 526637 526637 526637 52588 52570 52588 52577 5258 52577 5258 52577 5258 52577 5258 52577 5258 5258	21.47 21.60 21.66 21.50 21.63 21.57 21.52 21.55 11.31 11.42 11.36 11.32 11.31 11.42	163 433 476 411 482 427 179 202 186 185 177 126 79 111 76 78 77 93 76 87 70 65	2.91 1.88 2.99 1.788 1.798 1.697 1.6	1.71 1.63 1.52 1.58 1.58 1.58 1.53 1.52 1.09 1.04 2.572 1.04 1.39 1.73	1.88 1.62 1.88 1.60 1.82 1.71 1.52 1.60 1.65 1.67 2.28 1.44 2.22 1.68 2.25 2.03 2.43 2.53

· .				endry c (JOHO U/				
	·	Ţ	ט	Х	T	λ	C_{X}	$\mathtt{c}_{\mathtt{T}}$	Cλ
Program, Group, Serial Number	Date of Release, Run No.	Standard Altitude	Standard True Air Speed	Standard Range	Standard Time of Flight	Standard Träil		·	
Number		ft.	mi./hr.	ft.	sec.	ft.			
KS-138-15 16 17	5/4/395	, 2000	160	2580 2584 2589	11.26	62	3.00 3.33 3.91	2.61	3.00
18 19 20	8 9 10			2579 2583 2579	11.32 11.36	76 84	2.87 3.21 2.91	1.69	2.28
1 2 3	7/11/39-1	20000		7622 7622 7643	38.43 38.69 38.07	1396 1457 1291	1.47 1.47 1.52	1.25 1.15 1.42	1.35 1.29 1.47
4 5 6 7	4 5 6			7690 7622 7694	38.19 38.50 38.58	1271 1413 1360	1.65 1.47 1.66	1.36 1.22 1.19	1.50 1.33 1.39
7 · 8 · 9 · 10	7 8 11/17/39-1		*.	7587 7694 7666	38.32 38.38 38.23	1405 1313 1305	1.39 1.66 1.58	1.30 1.27 1.34	1.34 1.45 1.45
~ l 2	6/21/40-1	25000	200	7600 10519 10462	38.55	1447	1.42 1.46 1.38	1.20	1.30
4 5 7 8 9	7/5/40 / -2		_	10378 10664 10715	44.65	2433	1.28 1.72 1.83	1.01	1.27
8 9 10	3 4 5		'	10656 10589 10546	43.65 43.63 43.75	2149 2210 2288	1.70 1.58 1.51	1.28 1.29 1.25	1.46 1.41 1.37

-42

Appendix D

Mean Standard Elements of Altitude Groups and Relations between the Ballistic Coefficients and the Altitude of Release

Appendix D Table 1 Range

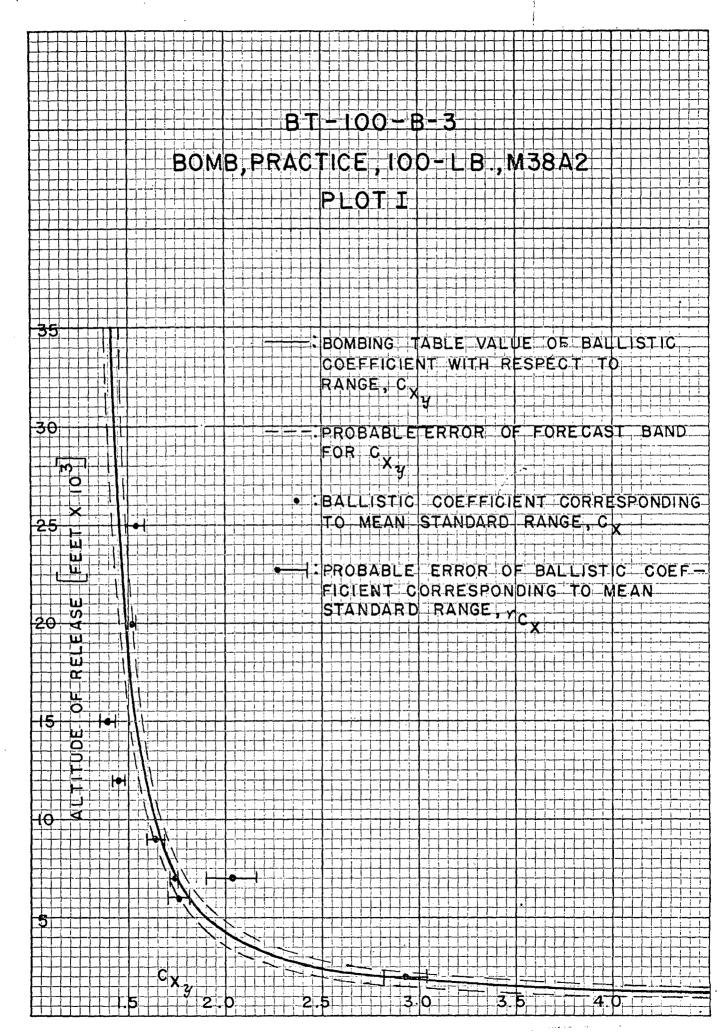
					1102160					
Y	υ	v	N	P	X	\mathtt{r}_{X}	c^X	$^{\mathtt{r}_{\mathtt{C}}}{}_{\mathtt{X}}$. C _X y	X-X _f
Standard Altitude		Calibrated Indicated Air Speed Corre- sponding to Standard True Air Speed	of	of	Mean Standard Range	Probable Error of Mean Standard Range	Ballistic Coefficient Correspond- ing to Mean Standard Range	Probable Error of Ballistic	Value of Ballistic Coefficient	Mean Standard Range Minus Range Corre- sponding to CX
ft.	mi./hr.	mi./hr.		·	ft.	ft.	٠,			ft.
35000 30000 25000 20000 15000 12000 10000 9000 7000 7000 6000 5000 2000	200 160 160 160 160 180 90 160	134.8 116.7 126.3 132.4 138.8 161.2 80.6 145.5	8 10 11 9 11 10 10	0.56 0.88 0.77 0.63 0.77 1.75 0.88	10566 7644 6623 5980 5256 5246 2670 4347 2580	26.9 8.5 13.7 8.4 7.3 3.2 5.1 6.2	1.54 1.52 1.39 1.45 1.64 1.73 2003 1.76	0.1045 0.021 0.037 0.029 0.042 0.022 0.128 0.061 0.110	1.41 1.43 1.46 1.49 1.54 1.59 1.67 1.75 1.82 1.90 2.82	53 14 -51 -37 -6 13 11 27

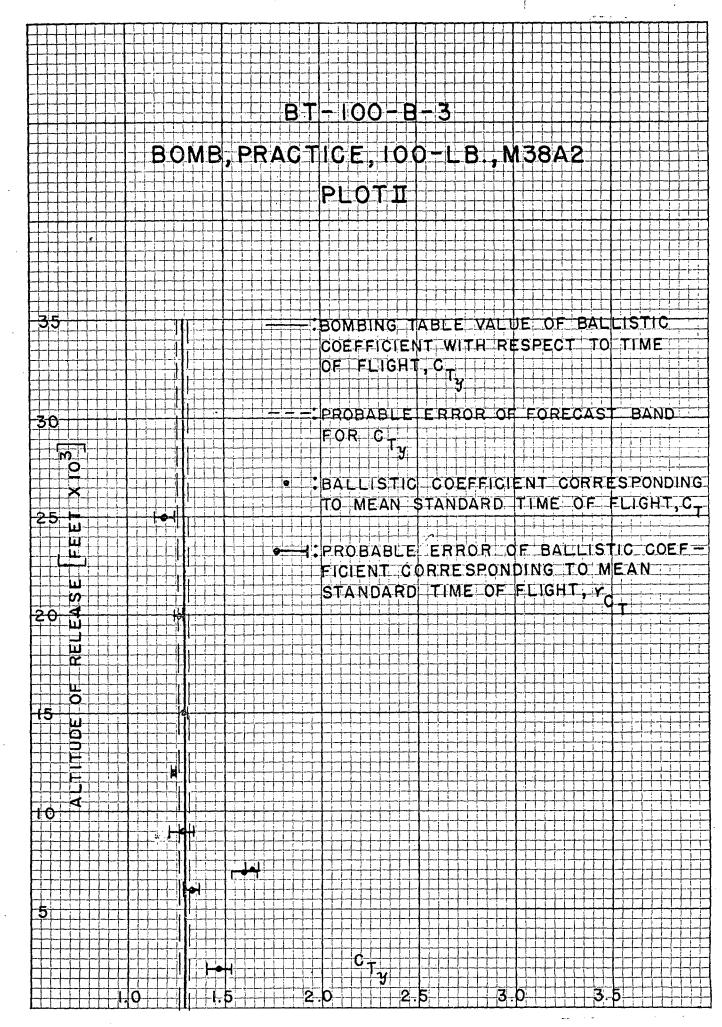
Appendix D
Table 2
Time of Flight

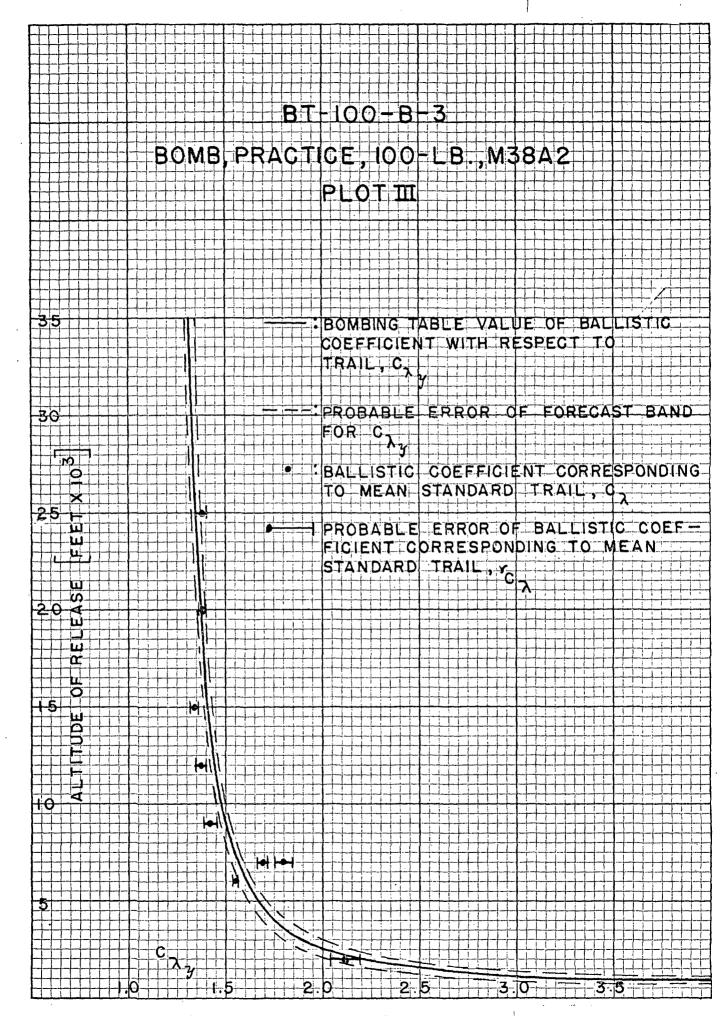
	Time of Flight										
Y	υ	V.	N.	·P	T	${ t r}_{ m T}$	\mathtt{C}_{T}	$^{\mathtt{r}}$ C $_{\mathtt{T}}$	C _T y	T-T _f	
Standard Altitude	Standard True Air Speed		of	Weight of Groups	Mean Standard Time of Flight		Coefficient Correspond-	Probable Error of Ballistic	Value of Ballistic Coefficient	Flight Minus Time of Flight Corre-	
ft.	mi./hr.	mi./hr.		٠	sec.	sec.	·	riigiit	,	sponding to C _T y sec.	
35000 30000 25000 20000 15000 12000 10000 7000 7000 6000 5000 2000	200 160 160 160 160 180 90 160	134.8 116.7 126.3 132.4 138.8 161.2 80.6 145.5	10 11 5 7 10 10 10	0.56 0.88 0.77 0.63 0.77 1.75 0.88	43.92 38.39 32.71 29.06 24.88 21.60 21.52 20.04	0.164 0.042 0.049 0.018 0.056 0.015 0.029 0.022	1.19 1.26 1.29 1.24 1.28 1.64 1.60 1.33	0.050 0,018 0.020 0.013 0.060 0.034 0.071 0.040	1.29 1.29 1.29 1.29 1.29 1.29 1.29 1.29	0.30 0.06 0.00 0.07 0.02 -0.18 -0.11 -0.02	

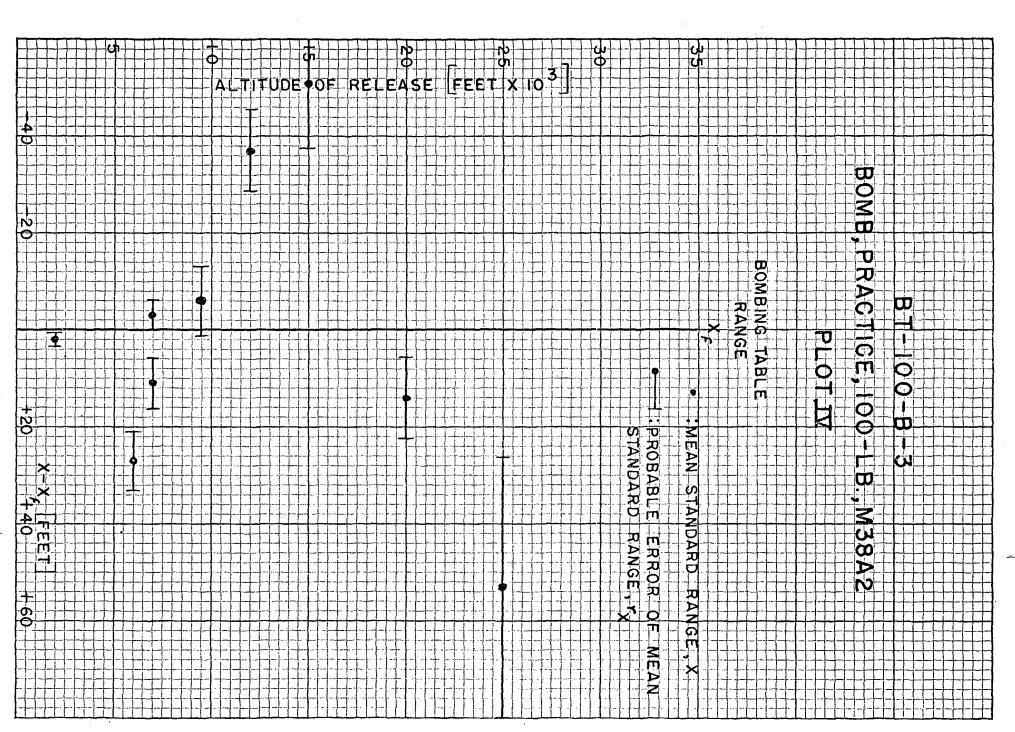
Appendix D
Table 3
TTrail

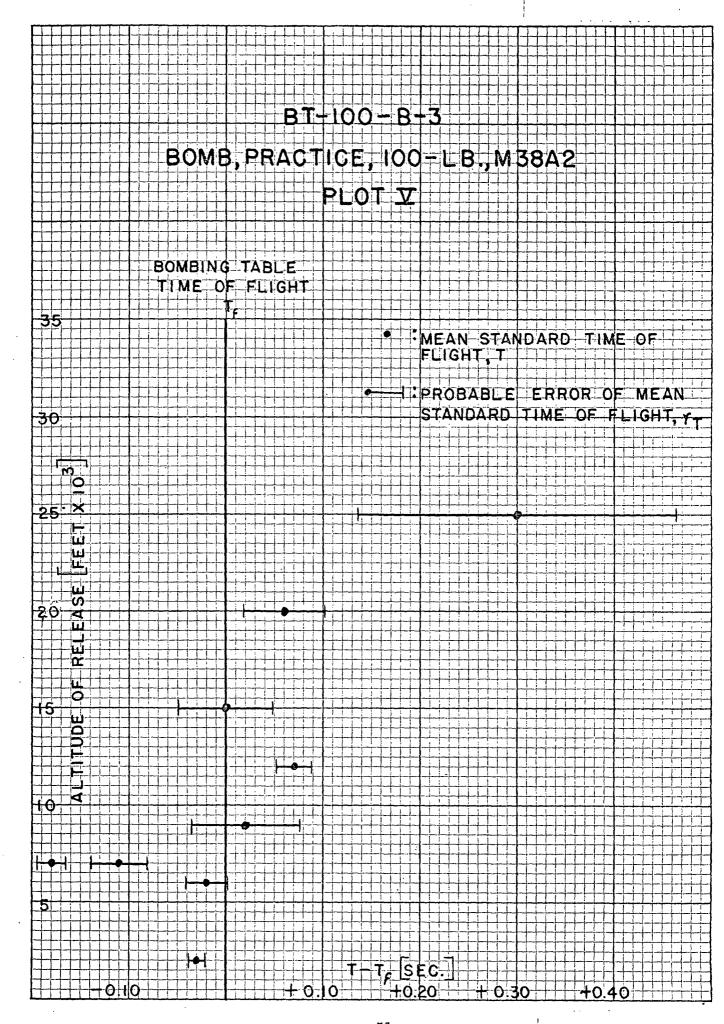
Y	ប	v	. N	P	λ	\mathbf{r}_{λ}	С _λ	$^{\mathbf{r}}$ C $_{\lambda}$	C _A	$\lambda + \lambda_{\mathbf{f}}$
Standard Altitude		Calibrated Indicated Air Speed Corre- sponding to Standard True Air Speed	of	Weight of Groups	Standard	Probable Error of Mean Standard Trail	Ballistic Coefficient Correspond- ing to Mean Standard Trail	Probable Error of Ballistic	Value of Ballistic Coefficient From C:Y Relation	Mean Standard Trail Minus Trail Corre- sponding to C _{\lambda}
ft.	mi./hr.	mi./hr.	٠.		ft.	ft.		``		ft.
35000 30000 25000 25000 15000 12000 10000 9000 7000 7000 6000 5000 2000	200 160 160 160 160 180 90 160	134.8 116.7 126.3 132.4 138.8 161.2 80.6 145.5	4 10 11 5 7 10 10 10	0.56 0.88 0.77 0.63 0.77 1.75 0.88	2270 1366 1053 822 600 457 170 357 77	41.4 14.3 16.6 15.0 16.6 5.4 4.5 3.9	1.38 1.38 1.34 1.37 1.42 1.69 1.80 1.55	0.028 0.015 0.022 0.026 0.040 0.028 0.048 0.017	1.32 1.33 1.35 1.37 1.41 1.45 1.48 1.50 1.56 1.60 1.66 2.20	-42 -9 51 41 39 -35 -20 12

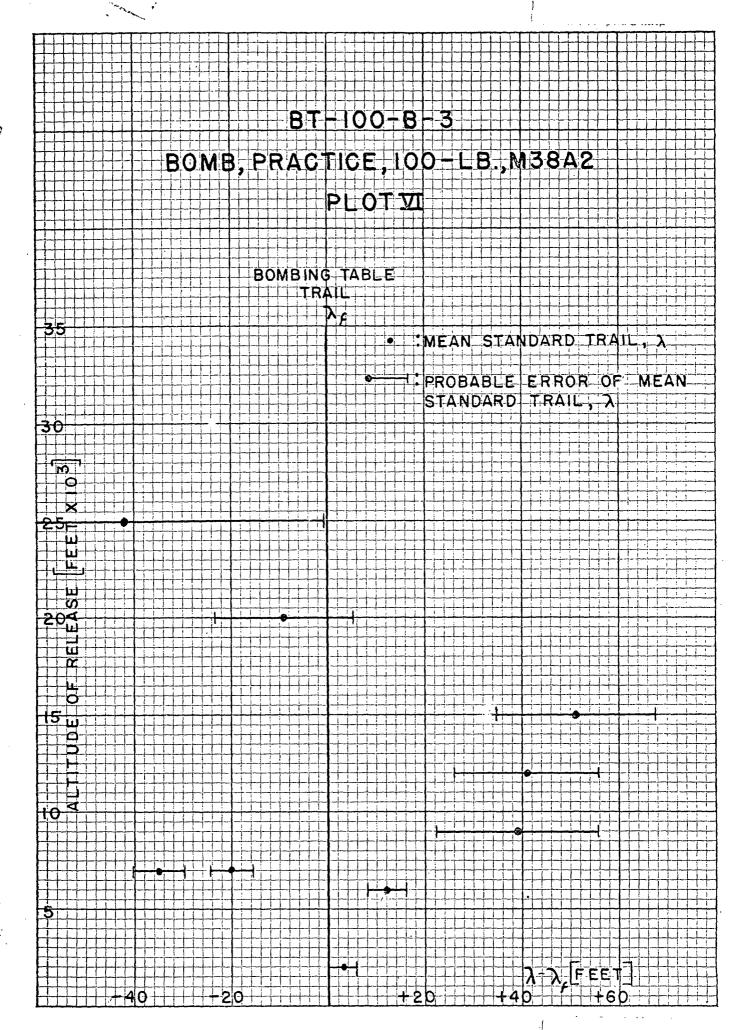












DRIGINATING AGENCY: Aberdeen Proving Ground, Ballistic Research Lab., Aberdeen, PUBLISHED BY: (Same) DATE March 142 ARSTRACT: This report contains the essential details of the experimental work, the computing methods and the experimental data upon which the bombing tables BT-100-B-3 for the M38A2 100-lb practice bomb are based. The bombs in this range bombing program were dropped from the B-18, B-4, B-4A, B-18A, and B-17B airplanes in accordance with the current standard bombing practice of the Air Corps using the standard bomb sight and a target in Bush River as an aiming point. The experimental data from which the ballistic coefficients with respect to range, time of flight and trail were determined, fell into 8 standard release altitudes: 25,000; 20,000; 15,000; 12,000; 9,000; 7,000; 6,000; and 2,000 feet. The methods used in range bombing, in obtaining the essential data, and in construction of the bombing tables are described. Graphs showing the results of range bombing, and the fitted ballistic coefficients as a function of the altitude of release are presented. DISTRIBUTION: Copies of this report obtainable from Air Documents Division: Attn: MCIDXD DIVISION: Ordnance and Armament (22) SECTION: Ballistics (12) ATI SHEET NO.: R-22-12-49 Air Documents Division, Intelligence Department **Air Material Command**